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(54) Title of the Invention: Cleaning Drying Processing Method

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Specification

1. Title of the Invention

CLEANING DRYING PROCESSING METHOD

2. Claim(s)

A cleaning drying processing method for cleaning a substrate to be processesed by providing a cleaning fluid to the surface of the substrate to be processesed while rotating the substrate to be processesed; then, draining off and removing a cleaning fluid attached to the surface of the substrate to be processesed by rotating the substrate to be processesed at a higher speed compared to the case of cleaning it; and heating the substrate to be processesed having the cleaning fluid removed by irradiating a light thereto and drying it; comprising the steps of:

irradiating a light on the surface of the substrate to be processesed upon the fluid-removing processing;

detecting a reflection light or a transmitted light from this surface; and

determining that the fluid-removing processing has been completed when a signal level of a detection signal of the above detection is kept approximately constant; and

then, carrying out the drying processing.

3. Detailed Description of the Invention

[Industrial Field of Application]

The present invention relates to a method for cleaning

a surface of a sheet-like substrate to be processed (hereinafter, referred to as "a wafer") such as a semiconductor wafer or a glass substrate and then, draining off and drying it.

[Prior Art]

Conventionally, for example, in JP-A-59-100540 (Title of the Invention: "Processing Method for Centrifugal Dryer Used for Processing of Silicon Wafer"), a processing method in a centrifugal dryer has been known (refer to Fig. 5), which serves to complete the drying processing by rotating a wafer stored in a basket at a low speed for a predetermined time (0 to t_2) while spraying water shower to the wafer; stopping the water shower and then, rotating the wafer at a high speed for a predetermined time (t_1 to t_2); and subsequently, spraying a nitrogen gas to the surface of the wafer for a predetermined time (t_2 to t_3) as being rotated at a high speed.

[Problems that the Invention is to Solve]

According to JP-A-59-100540, an inactive gas is provided so as to dry a surface of a wafer assuming that water drops on the surface of the wafer are drained off after a predetermined time (t_2 to t_1) from start of a high-speed rotation; however, it is necessary to obtain a predetermined time (t_3 - t_1) depending on a surface condition of the wafer, a material of a wafer, and a measurement of the wafer or the like each time by way of experiment and set them again.

On the other hand, in the case of drying the wafer by irradiating the light on the surface of the wafer in place of providing the inactive gas, there is a problem such that, if water drops remain on the surface of the wafer, this portion causes a spot. Therefore, it is necessary to dry the surface of the substrate due to irradiation of the light after draining processing of the surface of the wafer other than a minute concave part formed as a pattern is completely carried out and in order to do so, it is desired to accurately detect when the draining processing has been completed.

[Means for Solving the Problems]

The present invention is directed to a cleaning drying processing method for cleaning a wafer by providing a cleaning fluid to the surface of the wafer while rotating the wafer; then, draining off and removing a cleaning fluid attached to the surface of the wafer by rotating the wafer at a higher speed compared to the case of cleaning it; and heating the wafer having the cleaning fluid removed by irradiating a light thereto and drying it; comprising the steps of: irradiating a light on the surface of the wafer upon the fluid-removing processing; detecting a reflection light or a transmitted light from this surface; and determining that the fluid-removing processing has been completed when a signal level of a detection signal of the above detection is kept approximately constant; and then, carrying out the drying

processing.

[Operation]

In the fluid-removing processing step, when the light is emitted to the surface of the wafer and a reflection light or a transmission light from the surface is detected, in a previous step of the fluid-removing processing step, the detection signal is changed in a large way due to a diffuse reflection or absorption or the like of the light on a surface of a water drop on the surface of the wafer. However, when interference is generated in the reflection light or the transmission light by a thin wafer film remaining on the surface of the wafer in a later step of the fluid-removing processing step; the detection signal is changed into a signal having a predetermined amplitude; and when the fluid-removing processing is completed with water located on a place other than a minute concave portion which is formed on the wafer surface drained off by a centrifugal force, the detection signal gets to have approximately the same amplitude. After completion of the fluid-removing processing has been detected, by irradiating the light on the surface of the wafer and drying it, it is possible to carry out even and complete drying processing of the wafer.

[Embodiment(s)]

A flow chart of a method according to this invention is shown in Fig. 1; a schematic diagram showing an embodiment of

an apparatus for implementing this flow chart is shown in Fig. 2; and an explanatory view representing a temporal change such as a number of rotations of wafer in each processing step of the flow chart shown in Fig. 1 is shown in Fig. 3.

In the schematic diagram of Fig. 2, a reference numeral 1 denotes a chuck for holding a wafer W and horizontally rotating it; a reference numeral 2 denotes a nozzle for supplying a cleaning fluid, which is hanged on the upper side of the chuck 1; and reference numerals 3 and 4 denote a fiber for projection and a fiber for optical reception, respectively, which are hanged on the inside surface of a surface processing chamber 5 so that one end of the fiber for projection and one end of the fiber for optical reception come close to the wafer W. In addition, on the bottom surface of the surface processing chamber 5, a drain tube for discharging a processing liquid 9 is disposed and on the side wall of the processing chamber, a pipe fitting for decompression 12 connected to a vacuum source (not illustrated) is arranged. Further, an upper cover body 5' of the processing chamber 5 is formed so as to be capable of being opened and closed by a transparent plate, and on the upper side thereof, an infrared light lamp 10 for drying a wafer and an ultraviolet light lamp 11 to be lighted according to need are arranged.

In addition, on the other end of the fiber for projection 3 and on the other end of the fiber for optical reception 4,

light emission means 7 such as a light emission diode or a semiconductor laser and photoelectric conversion means 6 are arranged, respectively. An output signal from the photoelectric conversion mean s/6 is inputted in control means 8 and depending on change of the signal from the photoelectric conversion means 6, it is possible to detect a surface processing state of the wafer W.

Fig. 6 is a block diagram showing an embodiment of this control means 8. At first, an output signal from the photoelectric conversion means 6 is converted into a digital signal by an A/D converter 82 via an amplifier 81 to be inputted into a CPU (a central processing unit) 83. The CPU 83 carries out a predetermined arithmetic processing, for example, differential processing, and the fluid-removing processing is completed when an output signal from the differentiated photoelectric conversion means 6 takes a value not more than a predetermined level for a predetermined period, so that a driving motor of the rotation chuck 1 is stopped via a rotation control circuit 84.

Hereinafter, the explanation will be given with reference to the flow chart shown in Fig. 1. At first, when the processing is started (step S_0), the wafer W held by the chuck 1 starts to be horizontally rotated. As shown in Fig. 3A, the number of rotations N in this time is changed from 0 to N_2 and the cleaning fluid is supplied from the nozzle 2 (Fig.

2) into the wafer W (step S_1).

After cleaning the surface of the wafer W at the number of rotations N_2 for a predetermined time (0 to t_2), the rotation N of the wafer W is changed from N_1 to N_2 ($N_2 \geq 2000$ rpm) to be shifted into a fluid-removing step (step S_2) where the water is drained off by a centrifugal force. At the same time as this shift to the fluid-removing step, irradiating the light on the surface of the wafer W from the light emission means 7 via the fiber 3 and inputting the reflection thereof in the photoelectric conversion means 6 via the fiber 4, change in the reflection light on the surface of the wafer W is inputted in the control means 8 as an electric signal V. Fig. 3B illustrates an example of an output signal V from the photoelectric conversion means 6. Since the light irradiated on the surface of the wafer is deflected while the water drops of the cleaning fluid remain on the surface of the wafer W, the light amount inputted in the fiber for optical reception 4 is largely changed, however, in the later step of the fluid-removing processing step where the water drops of the cleaning fluid are completely drained off from the surface of the wafer W other than a minute concave portion having a pattern formed thereon and the thin water film remaining on the surface of the wafer, the amplitudes of the output signal are fixed and when the water located on the place other than the minute concave portion is removed at last, the output signal V from

the photoelectric conversion means 6 equivalent to the optical reception amount is approximately fixed. A time t_2 when this output signal V is fixed is determined to be a time when the fluid-removing processing is terminated. For example, in the case of assuming that the numbers of rotations N_2 in Fig. 3A = 500 rpm, 1,000 rpm, 2,000 rpm, and 4,000 rpm, respectively, a time (t_2 - t_1)required for the fluid-removing processing is 60 seconds, 40 seconds, 25 seconds, and 15 seconds, respectively. In addition, for example, a time after predetermined hours from the time t_2 in Fig. 3B can be also determined as the time when the fluid-removing processing is terminated.

After such fluid-removing processing, irradiating the infrared light on the surface of the wafer W by means of the infrared light lamp 10, the surface of the wafer is dried (step S_4). Further, when the material of the wafer W is a silicon, it is preferable that a halogen lamp mainly including a light beam in an infrared area of a wave length 1.2 μm which is the most absorbable by a silicon substrate is used as the infrared light lamp 10.

Fig. 4 shows a graph of the number of rotations of the wafer W for explaining other embodiment according to the cleaning drying processing method of the present invention. Here, the drawing discloses the case that a function to detect an end point of the surface processing such as etching

processing is further added to the control means 8 (Fig. 2). Supplying an etching liquid from a nozzle which is not illustrated in Fig. 2 to the surface of the wafer W being rotated at a predetermined number of rotation N_2, a metal thin film on the surface of the wafer W is selectively etched and then, in this etching state, an end point of the etching processing is detected on the basis of change of the reflection light from the surface of the wafer W via the optical fibers 3 and 4, respectively.

Defining a time t_1 when the etching processing is terminated to be an end point (E. P.) so as to stop supply of the etching liquid and changing the number of rotations of the wafer W from N_2 to N_3, the cleaning fluid is supplied to the surface of the wafer W so as to clean the surface of the wafer W. After lapse of a predetermined time, supply of the cleaning fluid is stopped, the number of rotations is changed from N_2 into N_4, the cleaning fluid remaining on the surface of the wafer W is drained off, and then, in the same way as described above, detection of the end point of the fluid-removing processing is started at the same time. After that, defining a time t_3 when an amount of the reflection light of the wafer W inputted in the fiber 4 is fixed as a time when the fluid-removing processing is terminated and then, irradiating an ultraviolet light on the surface of the wafer W till a predetermined time t_4 by means of a lamp 11, organic and

inorganic impure substances are discomposed.

Next, changing a rotating velocity of the wafer W from N_4 into N_2 and supplying a pure water to the surface of the wafer W, a discomposed impure substance on the surface of the wafer W is removed from the surface of the wafer W. Further, to superimpose this pure water cleaning and the ultraviolet light for a predetermined time is rather preferable for decomposition and removal of the impure substance.

After cleaning the surface of the wafer W for a predetermined time (t_4 to t_5) by a pure water and supplying a solvent medium such as I. P. A. (isopropyl alcohol) to the surface of the wafer, this solvent medium is replaced with the water remaining on the surface of the wafer.

In addition, when supplying a solvent medium such as this I. P. A. to the surface of the wafer W, when an ultraviolet light is irradiated at the same time as this supply, the solvent medium such as I. P. A. is discomposed, so that the ultraviolet light irradiation and the solvent medium supply are controlled so as not to be superimposed with each other.

Next, changing the number of rotations of the wafer W from N_3 into N_4 and entering the fluid-removing processing step again (t_6 to t_7), an end point of the fluid-removing processing is detected so as to terminate the fluid-removing processing. After termination of this fluid-removing processing, entering the drying processing step as the number of rotations of the

wafer W is remained N_4, the infrared light is irradiated on the surface of the wafer W by means of the lamp 10 for a predetermined time (t_7 to t_8).

Further, it is obvious that the above-described fluid-removing processing step and the drying processing step by means of the light irradiation can be effected in the decompression chamber.

Further, Fig. 7 is a schematic diagram showing other embodiment (the case of the transmitted light) of the method according to the present invention. Here, irradiating a light, for example, one having a main wave length of 1.2 μm from the light emission means 7 to the silicon wafer W, receiving the transmitted light thereof by means of the photoelectric conversion means 6, and inputting the transmitted light into the control means 8, it is possible to detect termination of the fluid-removing processing as well as the case of the reflection light.

[Advantage of the Invention]

When rotating the wafer at a high speed after cleaning it and drying the wafer by means of the light irradiation after the fluid-removing processing due to the centrifugal force, completed, problems that the wafer is rotated at a high speed beyond necessity or a stain is generated on the surface of the wafer by irradiating the light on the surface of the wafer with the cleaning fluid remaining on the surface of the wafer are

solved by appropriately detecting the end point of the fluid-removing processing, where by the fluid-removing processing can be practiced in the minimum fluid-removing processing time in response to the number of rotations of the wafer.

4. Brief Description of the Drawings

[Fig. 1]

Fig. 1 is a flow chart showing an embodiment for implementing a method according to the present invention.

[Fig. 2]

Fig. 2 is a schematic diagram showing an embodiment of an apparatus for implementing the method according to the present invention.

[Fig. 3]

Fig. 3 is an explanatory view showing an embodiment for implementing the method according to the present invention.

[Fig. 4]

Fig. 4 is an explanatory view showing other embodiment for implementing the method according to the present invention.

[Fig. 5]

Fig. 5 is a conventional explanatory view.

[Fig. 6]

Fig. 6 is a block diagram showing an embodiment of control means.

[Fig. 7]

Fig. 7 is a schematic diagram showing other embodiment for implementing the method according to the present invention.

W: wafer

1: rotation chuck

2: nozzle

3: fiber for projection

4: fiber for optical reception

5: surface processing chamber

6: photoelectric conversion element

7: light emitting means

8: control means

9: drainage tube

10: infrared light lamp

11: ultraviolet light lamp

12: pipe fitting for decompression

FIG. 1

S0: START

S1: CLEANING PROCESSING STEP

S2: FLUID-REMOVING PROCESSING STEP

S3: DETECT COMPLETION OF FLUID-REMOVING PROCESSING

S4: DRYING PROCESSING STEP

S5: END

FIG. 3

1: CLEANING PROCESSING STEP

2: FLUID-REMOVING PROCESSING STEP

3: DRYING PROCESSING STEP

FIG. 4

1: E. P. DETECTION

2: CORROSION STEP

3: CLEANING PROCESSING STEP

4: E. P. DETECTION

5: FLUID-REMOVING PROCESSING STEP

6: ULTRAVIOLET LIGHT IRRADIATION

7: IMPURE SUBSTANCE REMOVING STEP

8: PURE WQATER, SOLVENT MEDIUM

9: CLEANING PROCESSING STEP

10: E. P. DETECTION

11: FLUID-REMOVING PROCESSING STEP

12: INFRARED LIGHT IRRADIATION

13: DRYING PROCESSING STEP

FIG. 5

A: NUMBER OF ROTATIONS

B: WATER SHOWER AMOUNT

C: NITROGEN INJECTION AMOUNT

FIG. 6

LIGHT

6: PHOTOELECTRIC CONVERTER

81: AMPLIFIER

82: A/D CONVERTER

84: ROTATION CONTROL CIRCUIT